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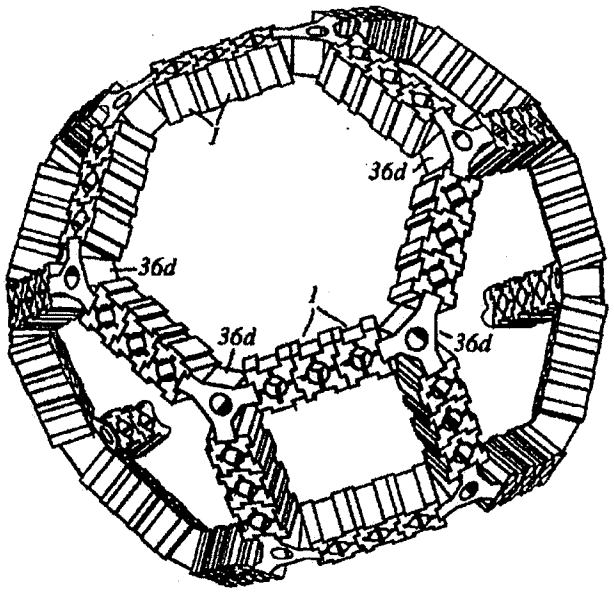
(54) Title: TOY CONSTRUCTION KIT WITH INTERCONNECTING BUILDING PIECES

(57) Abstract

Toy building pieces are disclosed which may be advantageously used in conjunction with a variety of different shaped framing pieces or connectors for building of structures such as polyhedral figures, geodesic domes or many other structures. One or more faces of the building pieces have interlocking means and have an aperture in the surface thereof to receive a thin rectangular shape such as a craft stick, or a circular shaped end of a framing piece of various cross section or connectors which are I-shaped in cross section. Other faces of the pieces may incorporate piece interconnection means, which may include for example: especially configured angular connection pieces which can be used in conjunction with other pieces to construct polyhedral figures; other pieces designed for hinged connection; a dovetail tongue on one part adapted to engage a dovetail groove on another part; or a tongue projecting from a face to engage one of the apertures. Other interconnecting means are also contemplated. In effect, adapter pieces are provided to change the connection means of a piece. In a kit or collection of such building pieces, a combination of various configurations of such pieces is provided.



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Title: TOY CONSTRUCTION KIT WITH INTERCONNECTING BUILDING PIECES

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to toy building blocks and in particular to interconnecting blocks which provide multiple connection means particularly suitable for constructing polyhedron or other geometric shapes.

In their preferred embodiment, the blocks may be used in conjunction with tubular or framing connectors with an I-shaped cross section, or other connectors, including tongues projecting from other blocks and specially configured connectors. Such connectors may be advantageously used in conjunction with craft sticks, 3/4 inch by 1/16 inch by six inches.

Description of the Prior Art

Toy building blocks of many different configurations are of course very well known and popular and have always been one of the most popular toys in a wide variety of cultures. The building blocks take many different forms and some of these forms have become extremely well known in association with their respective trademarks. The blocks employ various interconnection means to permit them to be snapped together in a fixed relationship in order to build structures.

Building toys also exist which employ hinged connections between the parts and a number of building toys employ connector pieces which permit structures to be assembled from larger framing pieces. Many prior art building toys have many obvious attractions and should not be criticised. However, there is always a demand for new building toys which may offer different possibilities from prior art. The inventor believes that the construction sets available on the market can still be more versatile, for example, a wall may be constructed similar to bricks with the most popular blocks with interconnection on two faces, although there are special pieces to expand in other directions, the blocks are not provided with an alternative for making a framed structure. On the other hand some construction sets provide outstanding framing features but the individual pieces cannot interlock to form a solid wall. The inventor also believes that most toy kits are limited if they were to be used to construct the many

attractive polyhedral and spherical shapes shown in some of our geometry books.

SUMMARY OF THE INVENTION

It is the object of the invention to provide a novel construction toy which will offer an attractive alternative to various prior art building blocks.

It is also intended to provide interconnecting building blocks that can be manufactured in thin-wall plastic, having a basically simple geometric shape interlocking in different directions and capable of a choice of framing pieces. Furthermore, additional pieces of other shapes and forms with interconnecting means suitable for assembly will be provided. These will construct many geometrical shapes such as polyhedral and circular structures which will be highly educational and very entertaining.

In agreement with the nature of the structural assembly with reference to the invention, the present arrangement begins from a cubical self-joining feature (which can be referred to as the **primary blocks**) which can be interconnected to form a larger three-dimensional planer surface. The blocks are not only self-interlocking but also have an extra capacity to use framing pieces and interconnecting pieces which are supplied with either a tubular or I-shaped cross-section or other interconnecting elements (such as plate-sections with appropriate tongues and compatible supports) including craft sticks, 3/4 inch by 1/16 inch by six inches and also 1/2 inch rounded wood-doweling. These supplemental options which are currently available will be of particular interest for children.

The invention includes a number of the primary blocks and other specifically designed pieces and connectors with interlocking capability. These pieces, with connectors, are provided in kit form.

At minimum, the primary blocks preferably have one or more faces designed with apertures to receive a connector or elongated framing projection with rounded ends or I-shaped cross section. For example, craft sticks (being 3/4 " by 1/16 " by six inches) can also be used. Other faces also incorporate means of joining blocks to each other to form larger building configurations.

Other interconnectors may include a pin projecting from one part, particularly sized to engage a sleeve incorporated in another part, for hinged union so that blocks may rotate with respect to each other. This pin and sleeve combination is slightly tapered so that a snug fit is achieved at full engagement, (referred to as **male hinge** and **female hinge** piece).

The interconnectors could also alternatively include a male dovetail tongue on one part, particularly sized to engage a female groove elsewhere. The said connection will enable one block to successfully engage with another.

In one configuration, the block is triangularly-shaped and has the unique advantage of interlocking with similar ones to form a circular array. A hexagon with a circular aperture, derived from this construction, is sized to engage the other rounded framing pieces of the kit. This offers an interlocking means for other pieces to radiate at various angles, (referred to as **triangle block**).

In another configuration, dovetail connections, arranged on the sides of the block, provide an alternate advantage allowing them to be interconnected in overlapping fashion, forming a matrix that structures the base for a self-expanding array.

A wedge-shaped block (referred to as **wedge block**) is included that can interconnect two primary blocks at a regular angle and a circular array may be formed when the pattern is continued. Some blocks (referred to as **vertex block**) may be added to the kit suitably designed to interconnect additional circular arrays offset around a common centre to form vertices. This can form the greater circles of a sphere.

Because of the specific design of the primary block (having interlocking faces circumferentially arrayed on four sides) it is now possible to develop an expansion in three-dimensions by appropriate angular manipulation of an elementary geometrical form. This is accomplished by a combination of the primary block and specifically shaped interconnecting pieces such as hubs containing tapered faces (referred to as **tapered hub**) radiating from a focal vertex through multiple spatial axes similar to the aforementioned spherical shape using wedge blocks. Also supplied are offset wedge blocks (referred to as **offset-wedge blocks**) and both the last mentioned blocks when used with other building pieces can be particularly useful for building configurations such as regular and semi-regular polyhedra. This application could also construct geodesic domes and spheres.

Further features of the invention will be described or will become apparent in the course of the following detailed description.

For convenience, the specification will refer to framing pieces. However, it should be clearly understood that this is intended to include any sticks having substantially the same general shape and dimensions as a craft stick and for that matter, any other connector or

elongated framing piece which could be engaged in the apertures within the blocks. As will be clear from the detailed description, craft sticks are just one example of the connectors which may be used. Connectors having an I-shaped cross-section could be used. Also, a tubular plastic framing piece may be used, or various cross-section wooden framing pieces with rounded ends as another example.

Also, the word "block" will be used generally for convenience, although the word "piece" will be used interchangeably. The word "piece" is perhaps more accurate, since not all of the pieces are shaped like a "block." Use of the word "block" is not intended to limit the invention to pieces which are shaped like a "block."

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, the preferred embodiment thereof will now be described in detail by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is an illustrative view of a polyhedral figure constructed with primary blocks and tapered hubs;

FIG. 2a is a top view of a tapered hub interconnecting piece as used in FIG. 1;

FIG.2b is a side view of the tapered hub that is shown in FIG.2a;

FIG. 3a is a perspective view of two primary blocks interlocked together;

FIG. 3b is a cross-sectional view of a primary block as shown in FIG. 3a;

FIG. 3c is an outline of the primary block as shown in FIG. 3a and showing the area for ejecting the block out of a mould;

FIG. 4 is a perspective view of a circular connector piece for use with the primary blocks shown in FIG. 3a;

FIG. 5a is a perspective view of a triangle block with interlocking means on three sides;

FIG. 5b is a cross-sectional view of the triangle block as shown in FIG. 5a;

FIG. 6 is a perspective view of an elongated connector piece which is commonly referred to as a **craft stick**;

FIG. 7 is a perspective view of an elongated connector which is I-shaped in cross-section;

FIG. 8a is a perspective view of a male hinge piece;

FIG. 8b is a perspective view of a female hinge piece;

FIG. 9 is a perspective view of a tongue to male dovetail interconnecting piece;

FIG. 10 is a perspective view of another primary block similar to FIG. 3a;

FIG. 11 is a perspective view of a short connector piece of I-shaped cross-section;

FIG. 12a is a cross-sectional view of a circular array of triangular blocks similar to the block shown in FIG. 5b;

FIG. 12b is a cross-sectional view of a matrix of primary blocks;

FIG. 13a-13c shows how the dovetail faces of the primary blocks are configured for the matrix shown in FIG 12b;

FIG. 14a is a perspective view of an assembly of wedge blocks and primary blocks using a four-way vertex block;

FIG. 14b is a perspective view of a wedge block as shown in FIG. 14a;

FIG. 14c is a cross-sectional view of a vertex block shown in FIG. 14a;

FIG. 14d is another choice of coring to that in FIG. 14c;

FIG. 15a is a perspective view of a dovetail interconnecting piece;

FIG. 15b is a view showing primary blocks and triangle blocks in a 60-degree and 180-degree configuration using a dovetail interconnecting piece;

FIG. 15c is another configuration of triangle and primary blocks;

FIG. 16 is view of primary blocks using framing pieces of circular cross-section;

FIG. 17a is a perspective view of a wooden framing piece with an alternate shaped body as used in the assembly shown in FIG. 18;

FIG. 17b shows the end view of FIG. 17a;

FIG. 17c shows the end view of FIG. 17a, if the framing piece were to be made of plastic;

FIG. 18 is a perspective view of a miniature store constructed with blocks and framing pieces;

FIG. 19 shows how angles are configured for the faces of a tapered hub using the outline of a tetrahedron;

FIG. 20a shows the top view of the tapered hub shown in FIG. 19;

FIG. 20b shows the side view of the tapered hub shown in FIG. 20a;

FIG. 21 shows an alternative angle configuration for the same size hub as in FIG. 19 but using the outline of a cube;

FIG. 22a - 22b shows another example of a tapered hub connector but uses a 4-way configuration;

FIG. 23a - 23b is similar to the hub piece as shown in FIG. 22a -22b but uses a 5-way configuration;

FIG. 24 shows an angle configuration for a vertex assembly as used on a dome structure similar to the one shown in FIG. 26;

FIG. 25 is a perspective view of an offset-wedge block as used in FIG. 24 and FIG. 26;

FIG. 26 is an illustrative view of a geodesic dome constructed with craft sticks, primary blocks and various offset-wedge blocks;

FIG. 27 is an illustrative view of dual polyhedra containing five-way vertex blocks.

FIG. 28 is an illustrative view of dual polyhedra containing four-way vertex blocks.

FIG. 29 is an illustrative view of a cubical assembly.

FIG. 30 is an illustrative view of a tapered hub made of plastic..

DETAILED DESCRIPTION

Reference is now made to FIG. 1 which is an illustrative view of a typical semi-regular polyhedron this one being the truncated octahedron constructed in accordance with the preferred embodiment of the present invention. The device being constructed by a combination of two different building pieces consisting of the primary block **1** and the tapered hub **36d**, It can be seen that the tapered hubs **36d** are interlocked with the primary blocks **1** conically around each vertex of the polyhedron. Also the polyhedron can be increased in size by adding more of the blocks uniformly to each face without changing the overall shape. The invention does not restrict the use of these blocks. For example, a customised piece, designed with two end connection means, could replace a string of primary blocks.

Fig. 2a shows the top view of the same hub **36d** and FIG. 2b shows its side view. As the polyhedron being shown is made up of hexagons and squares, the angles among the three edges at the vertex varies. This angle is referred to as **E.A. (edge angle)**. FIG. 2a shows the **E.A.** displayed between the male dovetails **9** and it shows a typical configuration of 131° 49′ between the two hexagon sections and the section making up the square being 96° 23 ′ these

angles are configured around a vertex line to the centre of the polyhedron. FIG. 2b also shows an angle **W.A. (wedge angle)** these two angles will be described in detail with FIG. 19 further on.

FIG. 3a is a perspective view of two primary blocks **1** interlocked together, the blocks each having one male dovetail **9** and three female dovetail faces **10**, each female dovetail being chamfered at the openings **10a** to ease location for a slide fit. The blocks have the unique feature of being able to form a new dovetail **9** from two correctly configured (see FIG. 12b) portions **9a**, **9b**, of the two blocks.

FIG 3b is a cross-sectional view of the block **1** and shows in more detail the shape of the aperture that passes through the two end faces. The circular opening **2** is split into four slots **20** and form a T-shape **25**, thus providing the block with the ability to receive a narrow rectangular or I-shaped connector piece, in any of four orientations at a 90-degree angle to each other. The same block can also receive a circular connector piece in the opening **2**, to give the block the unique advantage of receiving the choice of three different shaped connector pieces. Note that the male dovetail **9** of the said blocks is shown with a split, **15**. The purpose of the split is to provide a little flexibility in the male portion, for a smoother fit into the female portion.

FIG. 3c shows the outline of the primary block **1** which is shown in FIG. 3b. The four portions **5** make up the preferable area for a customised ejector tube slotted at **20**, to push against the plastic block enabling ejection from its mould-base.

FIG. 4 is a perspective view of a circular connector piece. Circular portion **3** is sized to fit the cavity **2** in the Block **1**. A circular plate **4** is provided to be accommodated within the recessed area **17** of the primary block, so that blocks can abut each other directly, rather than be separated by the thickness of the plate portion **4**. A rib **4a** is also shown, this is to locate the slot **20** of the blocks, thus preventing the blocks from rotating to each other when interconnected.

FIG. 5a is a perspective view of the triangle block **24**, which has two faces with female dovetail grooves **10**, the ends of the grooves being chamfered **10a** to ease assembly, the third face being a male dovetail tongue **9**. Each corner of the said block is arched **7** to provide a circular aperture when six blocks are interconnected to form a hexagon piece, (see FIG. 12a).

FIG. 5b shows a cross-sectional view of the triangle block **24** as shown in FIG. 5a.

FIG. 6 is a perspective view showing a craft stick **8** and FIG. 7 shows another elongated connector piece **14** which is I-shaped in cross-section. The reinforcing side walls **18** are used to strengthen the framing piece if manufactured in thin-wall plastic. A plate portion **21** spans between the side walls, and is intended to abut the block.

FIG. 8a and FIG. 8b are male and female hinge pieces, one having a pin and the other having a corresponding sleeve. A male pin **12** is offset from one block, and is adapted to mate with a female sleeve **13** incorporated into the other block. The pin and sleeve are slightly tapered such that a snug fit is achieved at full engagement between said pin and said sleeve. Female dovetail **10** and male dovetail **9** are also provided, although other forms of connection could be used if preferred. A portion **13a** is provided to act as a stop to limit the hinge swing and to align the hinges when closed. The stop **13a** can be eliminated if preferred and pin **12** and sleeve **13** may be positioned to give a swing equally in both directions.

FIG. 9 is a perspective view of a dovetail **9** to tongue **19** connector and showing a split **27**. FIG. 10 shows another primary block **1** and FIG. 11 shows a short connector piece **16** which is I-shaped in cross-section. It is essentially a short version of the elongated connector piece **14** shown in FIG. 7. Preferably the tongue **19** is split at a slot **27**. Thus as seen from FIG. 9 - 11, two connector pieces may be inserted in opposite ends of the same block, at a 90-degree angle to each other.

FIG. 12a is a cross-sectional view of a circular arrangement of triangle blocks **24** and FIG. 12b is an arrangement of primary blocks **1**, to demonstrate that the measurements of both groups of blocks have similar outer dimensions. Also note that the three primary blocks **1** are interlocked to form a matrix.

FIG. 13a - 13c shows how the dimensions of the primary blocks **1** are configured to form a new dovetail **9** from two correctly configured (see FIG.3a) portions **9a**, **9b**, of the two blocks.

FIG. 13a shows a side view of primary block **1** and dimension **C** is the mid-height or mid-depth distance across the female dovetail groove. The said female dovetail is chamfered at both openings **10a** and the mid-height or mid-depth distances at the outside edges are defined as **C + 2f** in which **f** is the distance of the chamfer at **10a**.

FIG. 13b -13c shows how the dimensions of the block are defined as follows. A nominal square of the side dimension **D** is defined by nominal lines drawn parallel to the side faces through mid-height or mid-depth points of the dovetail tongues or dovetail grooves as the case may be. The further dimensions of the block, as illustrated in FIG. 13c, are in accordance with the formulae:

$$A + B = C$$

$$A + B + C = D$$

Where **A** is the distance from one edge of dovetail tongue or dovetail groove at the mid-height or mid-depth thereof to its adjacent edge of the said nominal square; **B** is the distance from the opposite edge of the dovetail tongue or dovetail groove at the mid-height or mid-depth thereof to the adjacent edge of the said nominal square; and **C** is the width of the dovetail tongue or dovetail groove at mid-height or mid-depth thereof. Each dovetail tongue or dovetail groove is centred on the face of the nominal square, **D** being the length of each side of the square.

Further analysis of the above shows that **A = B**, and thus that **2A = C**, or **2B = C**, or **4A = D**, or **4B = D**, etc. It should be emphasized that these dimensions are all nominal, rather than precise. In practice, sufficient allowance must be made for normal tolerances and for drafts in mould to ensure that the mould can come apart and that the parts will engage each other without either too much or too little friction or play.

FIG. 13b illustrates how increasing the distance **C** by an amount **f**, drastically alters the configuration and the amount which are added onto a female dovetail groove is reduced on the male dovetail portions, making a loose fit.

FIG. 14a is a perspective view showing a configuration of primary blocks **1** and wedge blocks **22**. The wedge block **22** also shown in FIG 14b is provided with two male dovetails **9** on two opposite faces, decreasing in an acute angle. The wall thickness of the block is designed to use thin-wall plastic and may be ejected out of a mould by pushing around the circular portion (other bracing shapes could also be used) of the block **5a**. The block **1a** acts as the vertex block similar to the primary block **1** but contains all female connection means **10** as shown in the cross-sectional view FIG.14c or 14d. These end views of **1a** are ideal shapes for extruding longer pieces of the same profile. It is easy to form the greater circles of a sphere by using the vertex blocks and assembling two or more circular arrays of blocks. The vertex block could be provided with three or numerous female connection faces other than the four

shown in FIG. 14c.

FIG. 15a illustrates a male to male dovetail connector piece **31**, referred to as **male to male connector**.

FIG. 15b shows an arrangement of four primary blocks **1** that can be connected in a combination of 60-degree and 120-degree angles by using two triangle blocks **24** and a male to male connector **31**.

FIG. 15c shows more variations using a combination of primary blocks **1** and triangle blocks **24**. There can be numerous variations of structures to be achieved with the said blocks.

FIG. 16 illustrates an arrangement of primary blocks **1** with elongated circular framing connector pieces **28**. An optional shoulder **29** is provided and ends **3** are sized to fit the aperture **2** of the primary blocks **1**. The framing pieces **28** may be manufactured from tubular plastic, or from solid wood doweling.

FIG. 17a and FIG. 17b being the end view, illustrates an alternate elongated framing piece with similar end connections **3** and provided with the shoulder **29a** which uses a square section **28a** that can be made from wood. The square section **28a** is customised with slots **30** which can be used to support a thin rectangular plate if desired. The previously mentioned elongated framing pieces may have other configurations to support boards or plating sections at other angles if desired. FIG. 17c shows the end view of a customised connector similar to FIG. 17a - 17b designed for manufacturing in thin-wall plastic.

FIG. 18 is an illustration of a modular structure using interlocking primary blocks **1** and the use of framing pieces **28a** to support plate sections **32, 32a, 32b** and **32c** to form a structure of a miniature toy store. The framing pieces **28a** are slotted **30** on all four sides to receive the edges of the plating sections. The plates may be inserted between two framing pieces as shown with plate **32** or the plate as shown **32c** may be shaped to form a doorway **35**, or if desired, the plate could be customised to provide a window opening. The plates may also be supported by additional tongues **8a** that may be inserted into the cavities **20** of the primary blocks **1** (see FIG. 3b). The plates may be illustrated **34** (door-frame **34a**) by print or decals and may use transparent plastic to make shop windows. The boards may also be illustrated by the children with coloured pens.

Reference is now made to FIG. 19, FIG. 20a & 20b, and FIG. 21 which provides

more detail for configuring the tapered hub which is instrumental in the construction of polyhedra. A simple cube and tetrahedron are good examples for using a tapered hub combination. Beginning with the outline of the tetrahedron **38** shown in FIG. 19, the three male connecting faces **9** of the tapered hub **36a** radiate congruently around the axis from the centre **39** and the vertex **41** of this polyhedron. These three faces **9** will converge towards the vertex **41** and interconnect primary blocks **1** to be perfectly aligned with the outer edges of **40a, 40b, 40c - 41** of the tetrahedron and in a triangular plane **40a, 41** to the centre **39**. The converging angle is referred to as **W.A. (wedge angle)** and is configured as 1/2(180° - centre angle) which is 1/2 (180° - 109 ° 28′) being an angle of 35° 16′. The centre angle **C.A.** (defined as theta) is shown at the centre **39** of the tetrahedron **38** subtended by its edge **40a-41**.

It is interesting to note that the centre angle of a tetrahedron being 109° 28′ is the supplementary angle to that of a cube which is 70° 32′. Therefore by rotating the tapered hub **36a** end for end, they may be used for both polyhedra but the blocks are oriented at a 90-degree angle in the latter interconnections as shown in FIG.21. Because of this difference in orientation, it is now possible for the primary blocks **1** to be self-interlocking along the face edges **(48 to 51)** of the cube **42**. The interesting characteristics of this particular hub may be applicable to other structures such as the cuboctahedron or the octet truss.

As the tapered hub **36a** now converges to the centre **47** of the cube **42** as shown in FIG. 21, the wedge angle **W.A.** is now 1/2 the centre angle. The face edge **48-51** of the cube **42** can be seen to be subtended by the centre angle **C.A.**(defined as theta). The wedge angle **W.A.** is the angle at **X** between the centre axis **52** of primary block **1** and the centre axis **48** of the tapered hub **36a**.

FIG. 20a shows a top view of the tapered hub **36a** and three faces with male dovetail connector means **9** radiating equally around the hub centre axis. The circle **2** represents an aperture. Although not shown in detail, the sides of aperture **2** and the walls of the tapered hub may be manufactured in thin wall plastic. Also shown in FIG. 20a is edge angle **E.A.** (briefly mentioned in FIG. 2a) and is shown at a 120-degree angle suitable for the three-way vertices of the two regular polyhedra involved. These angles can vary in more complex polyhedra as displayed around the tapered hub used in the illustration of FIG. 1 and FIG. 2a. The configuration of a typical vertex is shown in FIG. 21 where the edge angle **E.A.** is measured

perpendicularly from a point (**B**) along the axis line from the vertex (**V**) to the polyhedral centre (**47**), subtended by the intersecting points (**43,44,45**) of the adjacent face edges (**46-49,46-50,46-51**).

The tapered hubs can produce even more complex polyhedra. Three of the five regular polyhedra use vertices that can be formed by using a three-way tapered hub **36a** . The octahedron can be constructed with a four-way hub **36b** as shown in FIG. 22a and 22b and the fifth regular solid being the dodecahedron uses a five-way hub **36c** as shown in FIG.23a-23b. The tapered hubs used to construct regular polyhedra will each have congruent wedge angles and edge angles. This is not true for the semi-regular polyhedra as previously mentioned.

As the polygons of the semi-regular polyhedra are not all the same, the vertex may share the edges of two hexagons and a square for example as shown in FIG. 1. Therefore, the hubs supplied for these polyhedra will have connection means at various edge angles around the hub centre axis, although the wedge angles may be congruent. Out of the thirteen semi-regular polyhedra known as the Archimedean solids, at least six contain vertices that can be constructed with three-way hubs with various edge and wedge angles and the remainder of the polyhedra may use four or five-way hubs. There are more polyhedra that may possibly be constructed by this method also.

As mentioned earlier, the tapered hub may support the primary blocks at a 90-degree angle difference in orientation using the tetrahedron as an example. This will then enable the tetrahedron to be constructed with elongated framing pieces connected between the blocks. Although this method is suitable for the tetrahedron, the taper angles of the hub are increased greatly when configured for the more complex polyhedra and it is preferable to use an alternative arrangement such as the **offset-wedge block**; now referred to in FIG. 24, FIG. 25 and FIG. 26.

When the offset wedge blocks **56c** as shown in FIG 24 are interconnected between a circular array of primary blocks **1**, they converge in a conic conjunction around a focal vertex **53a**. This method of forming a vertex with these offset-wedge blocks is useful if the primary block is to be supported with its apertures in line with the face edge of a geodesic dome or polyhedron, thus being able to utilize the elongated framing pieces.

As shown in FIG. 25, the offset-wedge block **56(a, b, c)** shows two male dovetail

faces 9 displaced with respect to independent angles (**T.C.A.** and **F.A.**) to each other. FIG. 24 shows **T.C.A.** (to the centre angle) as the angle formed by the projection of two lines from the points **58,59** (which are midpoints of the face edges being at 90-degrees in relation to the craft sticks **8**) so constructed to intersect at the centre point **57** of the sphere or polyhedron under construction. The second angle which is referred to as **F.A.** (face angle) is the angle between two face edges (**54,55**) at the vertex point **53a**.

FIG. 26 is an illustration of a geodesic dome constructed with radial configurations of five **53b** and six-way **53a** vertex assemblies similar to FIG. 24 as mentioned. The dome structure also uses elongated framing pieces **8** and by increased length the dome can be enlarged without changing the angular integrity or shape. The dome is based on the Archimedean semi-regular polyhedron, specifically the icosidodecahedron consisting of 12 pentagons and 20 triangles.

Five craft sticks **8** supported by primary blocks **1** unite the five vertices **53a** to form the perimeter of the pentagon. The said pentagon is subdivided by five triangles consisting of craft sticks **8** supported by two primary blocks **1** interconnected by two offset-wedge blocks **56b** at the base and further craft sticks radially supported by primary blocks **1**, interspersed by offset-wedge blocks **56a** at the focal vertex **53b**. The neighbouring triangles around the pentagons configuring this respective polyhedron, are similarly arranged in like format using a third customised offset-wedge block **56c**. The combinations of these three wedge blocks are the essentials necessary for the structural configured surface of this geodesic dome.

FIG. 27 is an illustration of a dual polyhedra **60a** using the configuration of the dodecahedron which uses a three-way tapered hub **36e** having a 120-degree edge angle and a wedge angle of 20°54′ which is interconnected with four-way blocks **1a** also shown in FIG. 14c. This block acts as the fundamental building piece for forming the thirty edges of the dodecahedra and thirty edges of the icosahedron by interconnecting with the five-way vertex configuration (**1c, 22a**). This five-way vertex is made up of a five-way block similar to the four-way block **1a** and this is made into a five-way tapered hub by interconnecting five wedge blocks **22b** which has a 31° 43′ angle. This could be replaced by a one-piece hub assembly **36c** as shown in FIG. 23a if so desired. By connecting more primary blocks **1** to the four-way blocks **1a** the complete configuration can be scaled up without compromising the established

shape and angular integrity. The tapered hub assemblies (**36e**,**22a**, **1c**) and the four-way blocks **1a** are all provided with apertures **2**. This total of sixty-two apertures can support round framing pieces **28** as shown in FIG. 16. These framing pieces will radiate outwards in the vector configuration of the dual polyhedra and can be used to support tapered hubs to form even larger dual polyhedra or a single dodecahedra with 20 vertices or icosahedra with 12 vertices. The geometry books will show that the intersection of edges (being the apertures of the four-way blocks **1a**) will also be aligned to the 30 vertices of the quasi-regular icosidodecahedron.

FIG. 28 is another illustration of an alternate spherical combination **60b**, this one shows the cube and octahedron in a duelling configuration. This assembly now uses four-way blocks **1a** with four 45-degree wedge blocks **22** to form a tapered hub assembly and it takes six of these assemblies to form the octahedra. The duelling cube however uses eight three-way hubs **36a** which needs a wedge angle of 35° 16′ to interconnect with the octahedra. The edges of this dual polyhedra again uses a four-way configuration **1a** as described in the FIG. 27 for the five-way dual polyhedra. The tapered hubs **36a** and four-way blocks **1a** all contain the apertures **2**. In this configuration there are twenty-six aperture supports for framing pieces with vector configurations of the cube, octahedra, and the quasi-regular cuboctahedron with its 12 vector equilibrium.

This combination is more versatile than the previous icosahedron dual configuration. Our geometry books reveal the three-dimension tessellation properties that belong to the tetrahedron and octahedron. This versatility can be proven by the endless configurations that can be assembled using individual pieces that make up the cube and the octahedra dual combination. A good example is shown as follows:

FIG.29 is an illustration showing a portion of an assembly of eight cubes to be built into a larger cubical formation. It can be seen that these vertex interconnections of the cubes are made up of blocks **1a** and 45-dergree wedge blocks **22** which can form the spherical structure similar to FIG. 28. The framing pieces **28b** makes up the side edges of the cube. It can be seen that using the framing pieces **28c** the hypotenuse of the cube can be formed. This breaks down this configuration into individual tetrahedrons. It can be also seen that by using the tapered hubs **36a** a structure as shown in FIG. 28 can be formed. Further to this, by

interconnecting the tapered hubs with framing pieces **28d** the diagonals of the cube can be achieved and this breaks down the configuration into individual octahedrons. It is therefore obvious that the three-dimensional tessellation can be formed not only with cubes but with tetrahedra and octahedra combinations using these building pieces.

FIG.30 is an illustration of the tapered hub **36a** which can be manufactured in thin wall plastic. The aperture of this hub is made similar to that of the four-sided block but the aperture **2** is split three-way, this allows for a flexible fit for framing pieces. A bridge **61** is also provided to brace the centre area for firmness. Also shown are the top profiles **62a** and bottom profiles **62b** of the hub **36a**. Each of these profiles could also be used as end profiles of parallel faced connecting pieces and extruded to any length.

Although the previous examples show polyhedra and a geodesic dome,.this does not restrict the invention to these shapes. With the appropriate angular configurations of the conical assemblies and framing features, it is possible to form any three dimensional models with a framed mesh similar to computerized surface modelling. A water soluble adhesive could be used to secure the interconnections uniting the models and then removed again by soaking in water.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

I claim:

(1) A toy construction kit used for building structural frames of surface models and polyhedral figures, comprising a fundamental building piece having interconnection means with essentially dovetail elements running theralong a pair of opposite faces with the option of a second pair of similar faces equally displaced at right angles about a common axis. At least three of the said fundamental building pieces may be engaged with complimentary interconnections on other shaped building pieces. These said other shaped building pieces provide at least two faces with the said complementary interconnection means which are essentially dovetail elements configured and angularly offset about two axes. This enables the construction of a self-supporting conical assembly about a focal vertex. The said conical assemblies, with appropriate angles, can be mutually interconnected to form a framework in the configuration of at least 3 face-edges from any one of the following group of geometrical choices consisting of:

(a) regular polyhedra;

(b) semi-regular polyhedra;

(c) dual polyhedra;

(d) quasi-regular polyhedra; and

(e) asymmetrical-faced polyhedra.

These said frameworks can be formed and proportionally enlarged, without compromising the established shape and angular integrity of the said frameworks, by virtue of at least one of the following specifications selected from the group consisting of:

(a) by increasing the lengths of the said fundamental building pieces for mutual interconnection of the said conical assemblies;

(b) by adding to a sequence of self-interconnected said fundamental pieces for mutual interconnection of the said conical assemblies;

(c) by adding to a sequence of interconnected said fundamental pieces and said other shaped building pieces for mutual interconnection of the said conical assemblies; and

(d) by increasing the length of an elongated framing connector piece which is supported at both ends by an aperture within a third face of the said fundamental building piece. This provides for a mutual interconnection of the said conical assemblies.

(2) A toy construction kit as recited in claim 1, where the said other shaped building pieces include ones comprising two faces, each one having a male dovetail element running therealong. These said faces are offset at a specific angle about their common axis and converge to a focal point at a second specific angle in the same said axis.

(3) A toy construction kit as recited in claim 1, where the said other shaped building pieces include ones comprising at least three faces, each one having a male dovetail element running therealong. These said faces are offset at various angles about their common axis and converge to a focal point at a second specific angle in the said axis to form a frustrum-shaped hub.

(4) A toy construction kit as recited in claim 3, wherein at least one additional face of the said frustrum-shaped hub is provided with a cylindrical aperture configured with its inner wall arranged around the said axis toward the said focal point.

(5) A toy construction kit as recited in claim 1, where the said other shaped building pieces include pieces comprising between three and six faces, each one having a female dovetail element running therealong equally displaced about their common axis. These said female elements are engaged with specifically designed offset wedges, each one possessing two male offset faces. This configuration forms a frustrum-shaped hub combining a minimum of three male dovetail elements radiating from a common focal point.

(6) A toy construction kit as recited in claim 5, wherein at least one additional face of the said other shaped building piece is provided with a cylindrical aperture configured with its inner wall arranged around the said axis toward the said focal point.

(7) A toy construction kit as recited in claim 1, wherein the said fundamental building pieces include six-faced building pieces which have four side faces and two opposite end faces. Also, each one of the said side faces presenting a dovetail element running therealong, particularly sized to engage a corresponding dovetail element on another piece, such that one piece engages with another piece.

(8) A toy construction kit as recited in claim 7, wherein at least one additional face of the said other fundamental building piece is provided with a cylindrical aperture configured with its inner wall arranged around the said axis toward the said focal point.

(9) A toy construction kit as recited in claim 4, 6 and 8, wherein the said cylindrical aperture configured with selective arcs which are inherently longitudinal throughout the building pieces, the said aperture being particularly sized and shaped to receive at least one connector member of the said kit from the following group consisting of:

(a) a planar, essentially rectangular cross-section elongated element and a planar, essentially rectangular cross-section integral tongue extending from another building piece;

(b) a planar, essentially I-shaped cross-section elongated element and a planar, essentially I-shaped cross-section integral tongue extending from another building piece;

(c) a planar, essentially circular cross-section elongated element and a planar, essentially circular cross-section integral tongue extending from another building piece.

(10) A toy construction kit as recited in claim 3, claim 5, and claim 7, where a minimum of twelve of the said fundamental building pieces will construct a complete dual polyhedron in the configuration of a cube and a regular octahedron, when interconnected with the total number of said frustrum-shaped hubs set forth in the following two groups:

(a) six of said frustrum-shaped hubs each being provided with four said male dovetail elements converging at a 45-degree angle and positioned in a regular array about a common axis towards the centre point of the said dual polyhedra;

(b) twelve of said frustrum-shaped hubs each being provided with three said male dovetail elements converging at an angle of 35° 16′ and positioned in a regular array about a common axis toward the centre point of the said dual polyhedra.

(11) A toy construction kit as recited in claims 3 to10, wherein said apertures are provided for the said fundamental building pieces and frustrum-shaped hubs that form the spherical assembly of the said dual polyhedra. These apertures being aligned precisely to the said centre point providing support means for a maximum of twenty-six said connector members. Selected assemblies of connector members providing vector configurations from the inner said spherical

assembly and support for the construction of additional polyhedra as defined by the following group:

(a) the cube with eight central vectors;

(b) the regular octahedron with six central vectors; and

(c) the quasi-regular cuboctahedron with the twelve central vector equilibrium.

(12) A toy construction kit as recited in claim 3, claim 5 , and claim 7, where a minimum of thirty of the said fundamental building pieces will construct a complete dual polyhedron in the configuration of a regular icosahedron and a regular dodecahedron when interconnected with the total number of said frustrum-shaped hubs set forth in the following two groups:

(a) twelve of the said frustrum-shaped hubs each being provided with five said male dovetail elements converging at an angle of 31° 43′ and positioned in a regular array about a common axis toward the centre point of the said dual polyhedra;

(b) twenty of the said frustrum-shaped hubs each being provided with three said male dovetail elements converging at an angle of 20° 54′ and positioned in a regular array about a common axis toward the centre point of the said dual polyhedra.

(13) A toy construction kit as recited in claims 3 to 9, and claim 12, wherein said apertures are provided for the said fundamental building pieces and frustrum-shaped hubs that form the spherical assembly of the said dual polyhedra. These apertures being aligned precisely to the said centre point providing support means for a maximum of sixty-two said connector members. Selected assemblies of the said connector members providing vector configurations from the inner said spherical assembly and support for the construction of additional polyhedra as defined by the following group:

(a) the regular dodecahedon with twenty central vectors;

(b) the regular icosahedron with twelve central vectors;

(c) the quasi regular icosidodecahedron with thirty central vectors.

(14) A toy construction kit, comprising a plurality of building pieces of various configurations, including building pieces each having six faces, each one of the said six faces having interconnecting means configured for direct connection to complimentary interconnection

means on other building pieces, said interconnection means in at least one of the said faces comprising an interrupted cylindrical aperture configured with selective arcs arranged in regular array; the said aperture particularly sized and shaped to receive a connector member in the said kit from the group consisting of:

(a) a planar, essentially rectangular cross-section elongated element and a planar, essentially rectangular cross-section integral tongue extending from another building piece,

(b) a planar, essentially I-shaped cross-section elongated element and a planar, essentially I-shaped cross-section integral tongue extending from another building piece,

(c) a planar, essentially circular cross-section elongated element and a planar, essentially circular cross-section integral tongue extending from another building piece;

the said other faces each having other interconnection means, including at least two selected from the group consisting of:

(a) a pin parallel to a face of a piece, particularly sized to engage a corresponding sleeve on another piece, for hinged connection such that one piece may rotate with respect to another piece;

(b) a sleeve parallel to a face of the piece, particularly sized to engage a corresponding pin on another piece, for hinged connection such that one piece may rotate with respect to another piece;

(c) a male dovetail on a face of the piece, particularly sized to engage a corresponding female dovetail on another piece such that one piece engages with another piece;

(d) a female dovetail on a face of the piece, particularly sized to engage a corresponding male dovetail on another piece such that one piece engages with another piece;

(e) a tongue of a rectangular cross-section projecting from a face of a piece, particularly sized to engage one of the said apertures;

(f) a tongue of an essentially I-shaped cross-section projecting from a piece, particularly sized to engage one of the said apertures; and

(g) a tongue of a circular cross-section projecting from a piece, particularly sized to engage one of the said apertures.

(15) A toy construction kit as recited in claim 14, where at least some of the said six-faced building pieces have four side faces and two opposite end faces having the said interrupted

cylindrical aperture which is configured with selective arcs arranged in regular array being inherently longitudinal throughout the building piece.

(16) A toy construction kit as recited in claim 15, where four side faces each have one of the said other interconnecting means, not all four sides having the same said other interconnecting means.

(17) A toy construction kit as recited in claim 15 where each one of the said side faces has a dovetail element running therealong, particularly sized to engage a corresponding dovetail element on another piece such that one piece engages with another piece.

(18) A toy construction kit as recited in claim 17, where said dovetail elements include both male and female.

(19) A toy construction kit as recited in claim 14, where the said kit further includes adapter pieces having two generally parallel faces in close proximity to each other, said faces of said adapter pieces each having interconnection means selected from the group consisting of:

(a) a pin parallel to a face of a piece, particularly sized to engage a corresponding sleeve on a piece, for hinged connection such that one piece may rotate with respect to another piece;

(b) a sleeve parallel to a face of a piece, particularly sized to engage a corresponding pin on another piece, for hinged connection such that one piece may rotate with respect to another piece;

(c) a male dovetail on a face of the piece, particularly sized to engage a corresponding female dovetail on another piece such that one piece engages with another piece;

(d) a female dovetail on a face of the piece, particularly sized to engage a corresponding male dovetail on another piece;

(e) a tongue of a rectangular cross-section projecting from a face of a piece, particularly sized to engage one of the said apertures;

(f) a tongue of an essentially I-shaped cross-section projecting from a piece, particularly sized to engage one of the said apertures; and

(g) a tongue of a circular cross-section projecting from a piece, particularly sized to engage one of the said apertures;

whereby said building pieces having six faces may have the type of interconnection means on any given face effectively changed by attaching one of the said adapter pieces, to change a face having an aperture into a face having an interconnecting means selected from the above group, or to change a face having other interconnecting means into a face having a tongue.

(20) A toy construction kit as recited in claim 19, where said adapter pieces include pieces comprising two said dovetails, one on each face.

(21) A toy construction kit as recited in claim 19, where the said adapter pieces include pieces comprising a dovetail and a tongue one on each said face.

(22) A toy construction kit as recited in claim 19, where the said adapter pieces include pieces comprising two faces, each one having a male dovetail element running therealong. These said faces are offset at a specific angle about their common axis and converge to a focal point at a second specific angle in the same said axis.

(23) A toy construction kit as recited in claim 19, further comprising at least two adapter pieces for hinged connections between any two building pieces, one said adapter piece having a pin projecting therefrom, particularly sized to engage a corresponding sleeve incorporated in the other adapter piece. Each of said adapter pieces have at least one other face with interconnection means for engagement with complimentary ones on another building piece. The said hinged connections thus provide for a hinged connection whereby one building piece or unit may rotate with respect to another piece or unit.

(24) A toy construction kit as recited in claim 14, further including said elongated connectors and such that they are at least five times as long as any dimension of those aforementioned building pieces having six faces. These said elongated connectors may be used to connect remote blocks via said apertures

(25) A toy construction set as recited in claim 14, comprising building pieces having two opposite faces, each having dovetail elements running therealong. The said faces converging at a specific angle to form a wedge-shaped interconnection piece.

(26) A toy construction kit as recited in claim 14, comprising building pieces where at least two adjacent side faces have either a dovetail tongue running therealong for engagement with a corresponding dovetail groove on another building piece or combination of building pieces, or a dovetail groove running therealong for engagement with a corresponding dovetail tongue on another building piece or combination of building pieces, such that one building piece engages with a building piece or combination of building pieces, in which a nominal square of side dimension D is defined by nominal lines drawn parallel to said side faces through mid-height or mid-depth points of said dovetail tongues or dovetail grooves as the case may be. The further dimension of the said building piece, ignoring minor allowances for tolerance and mould draft, are substantially in accordance with the formulae:

$$A + B = C \text{ and}$$

$$A + B + C = D$$

where:

A is the distance from one edge of the dovetail tongue or dovetail groove at the mid-height or mid-depth thereof to its' adjacent edge of said nominal square;

B is the distance from the opposite edge of the dovetail tongue or dovetail groove at mid-height or mid-depth thereof to its' adjacent edge of said nominal square;

C is the width of the dovetail tongue or dovetail groove at mid-height or mid-depth thereof;

where each said dovetail tongue or dovetail groove is centred on the face of the said nominal square.

(27) A toy construction kit as recited in claim 14, comprising building pieces where each face having one of said apertures has a portion of this face recessed into its' outer periphery.

(28) A toy construction kit as recited in claim 14, where said connector members further include I-shaped connectors each having an I-shaped cross-section defined by a main web and

two end arms, and a cross-web spanning between arms partway along the said main web.

(29) A toy construction kit as recited in claim 19, where the said adapter pieces include a triangular-shaped piece with three adjacent faces each of which said faces has a dovetail element running therealong.

(30) A toy construction kit as recited in claim 29, where the said triangular-piece is particularly sized and shaped to engage with corresponding dovetail elements on other said triangular pieces to form a six-sided hub piece. The said hub having an aperture along its' centre axis particularly sized to receive an elongated framing piece of circular cross-section.

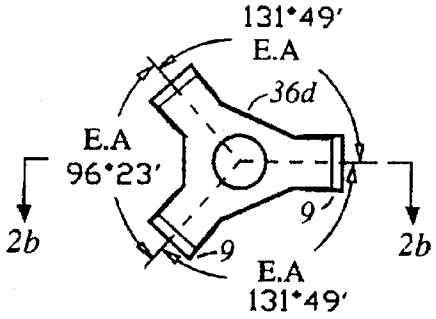


FIG.2a

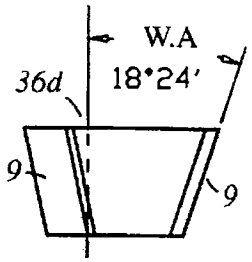


FIG.2b

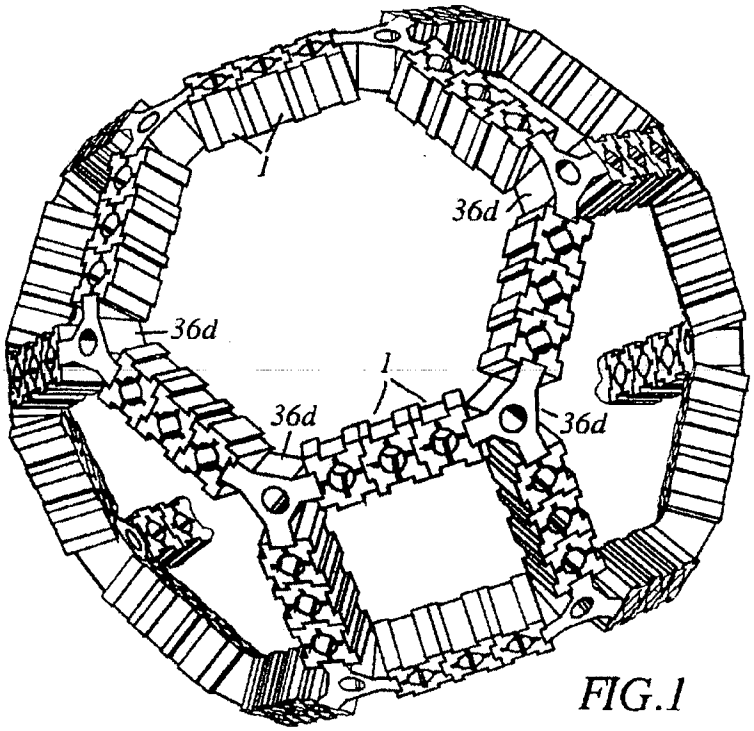


FIG.1

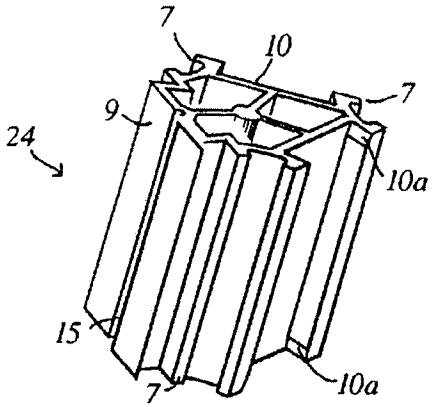


FIG.5a

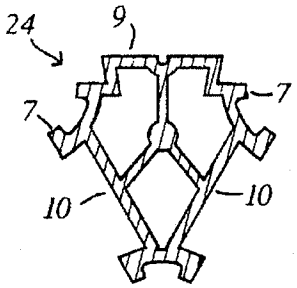


FIG.5b

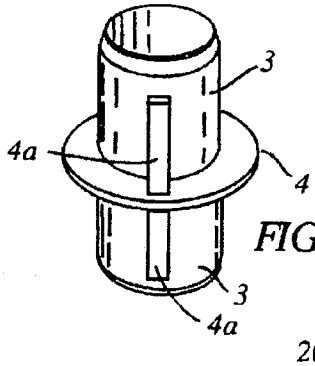


FIG.4

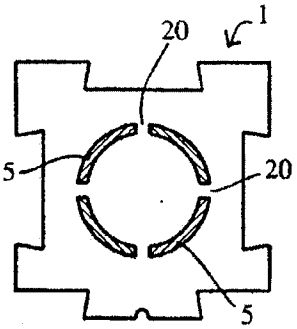


FIG.3c

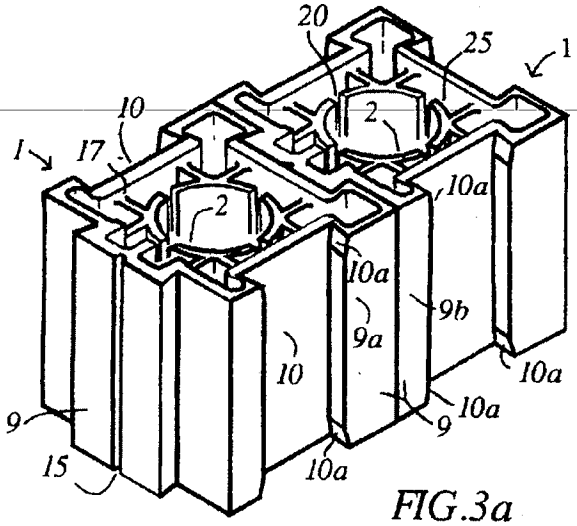


FIG.3a

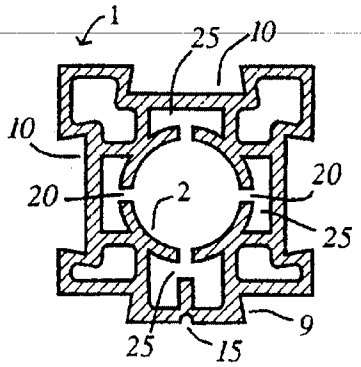


FIG.3b

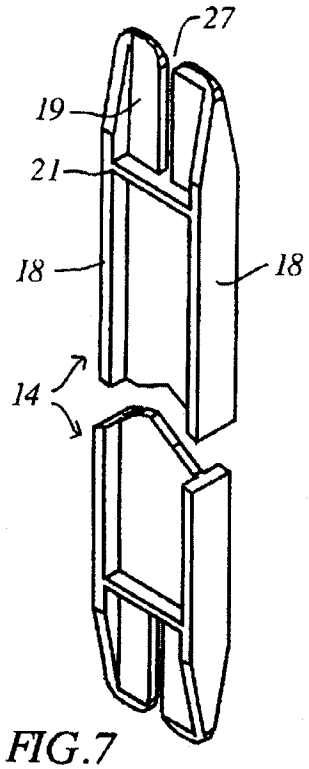


FIG.7

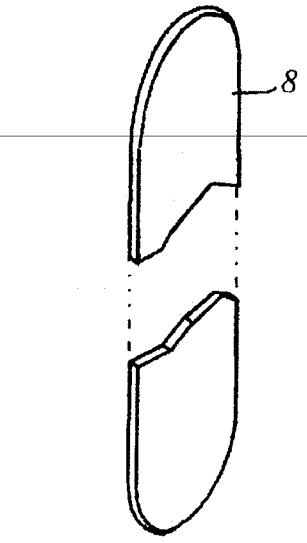


FIG.6

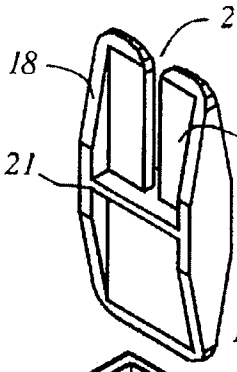


FIG.11

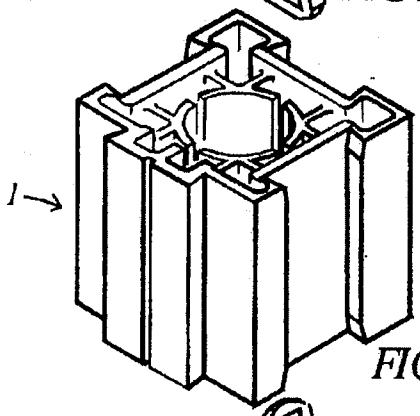


FIG.10

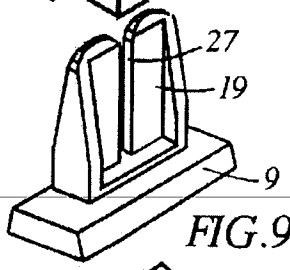


FIG.9

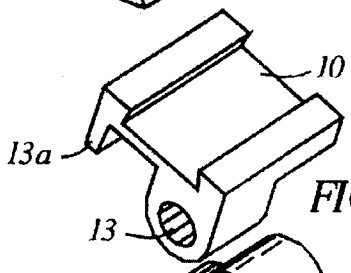


FIG.8b

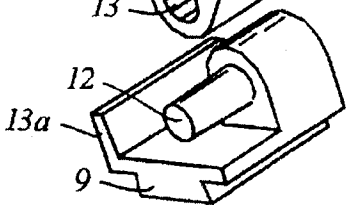


FIG.8a

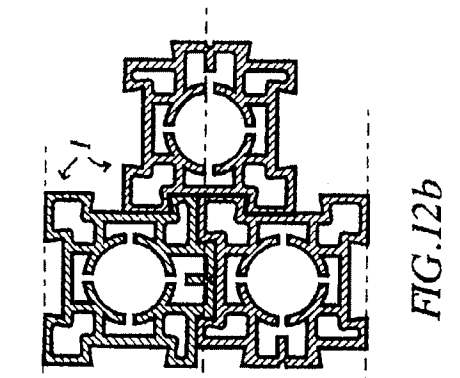


FIG.12b

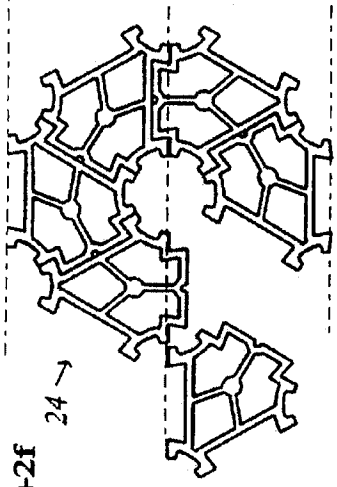


FIG.12a

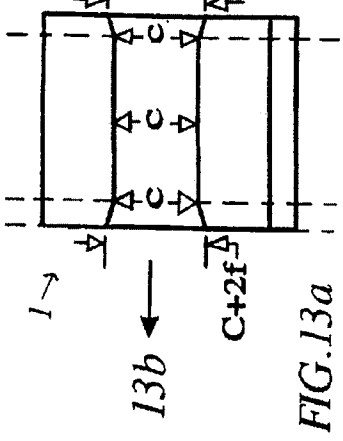


FIG.13a

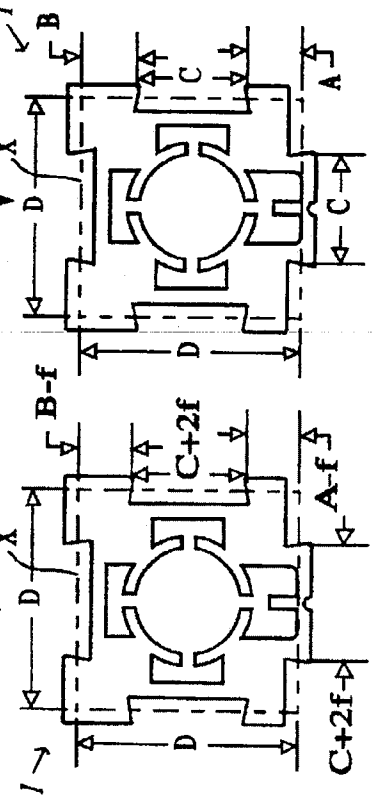


FIG.13b

FIG.13c

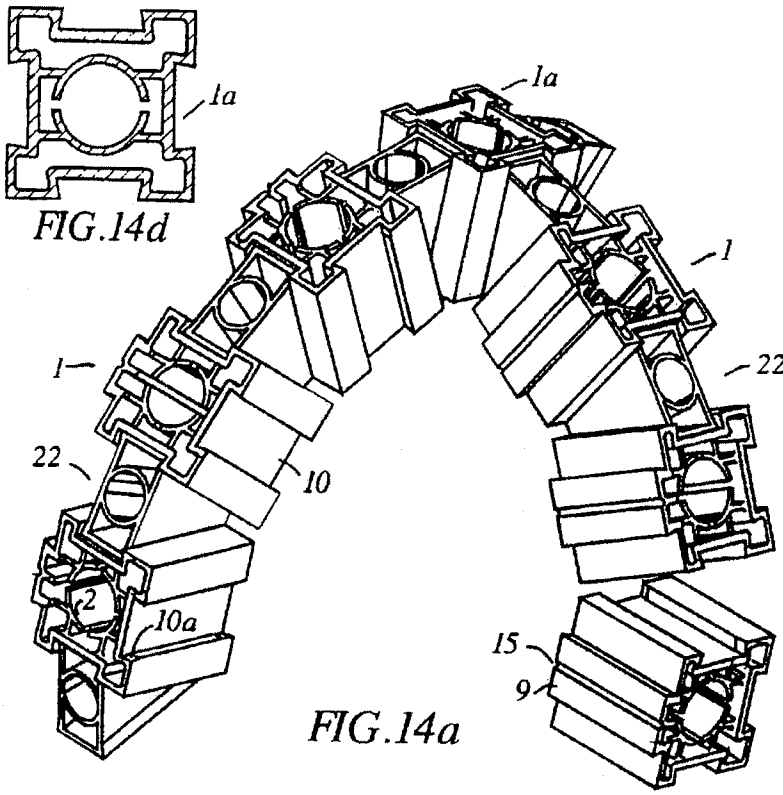


FIG.14a

FIG.14d

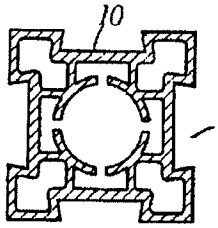


FIG.14c

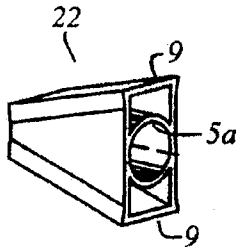


FIG.14b

FIG.15a

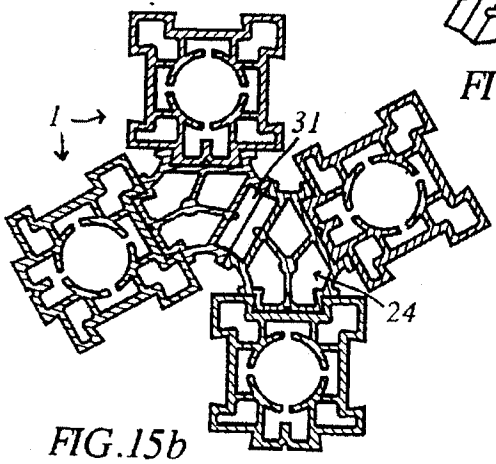


FIG.15b

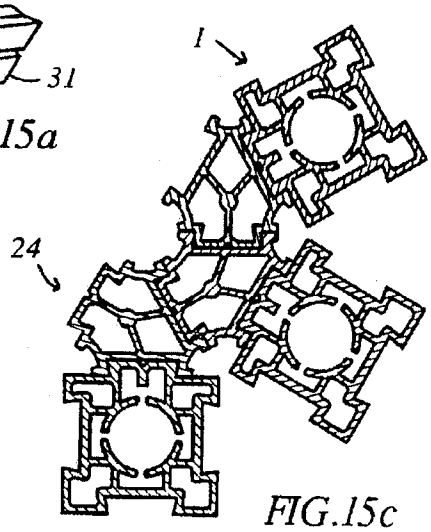


FIG.15c

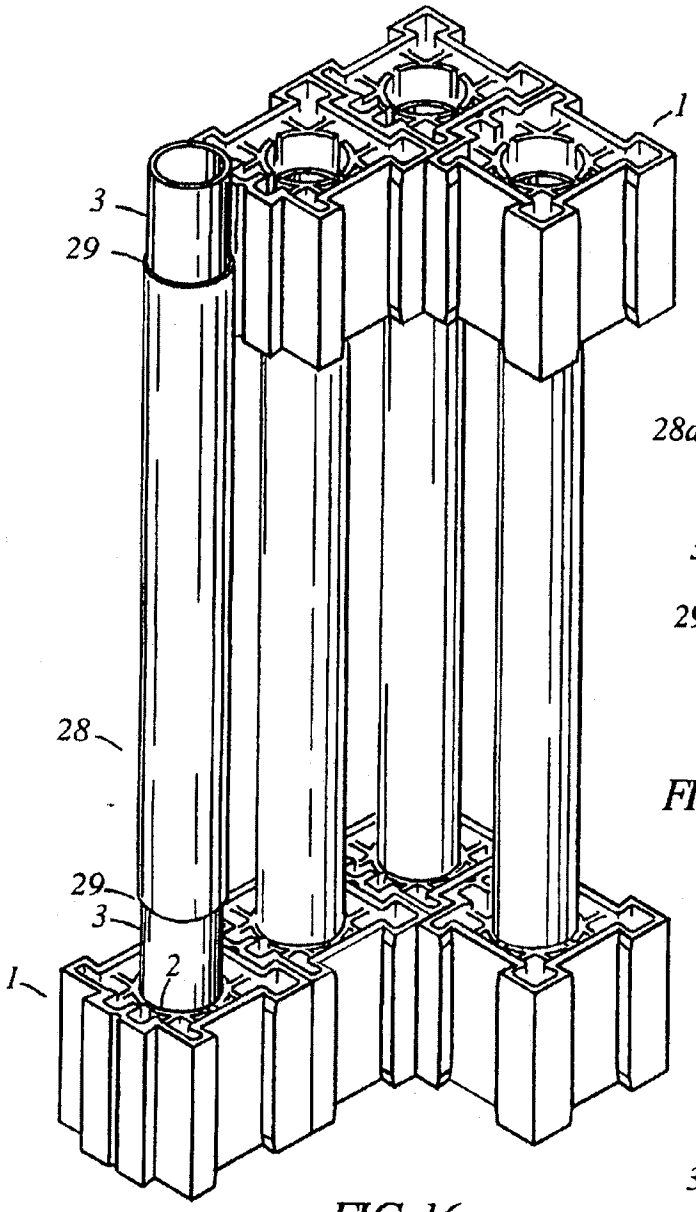


FIG.16

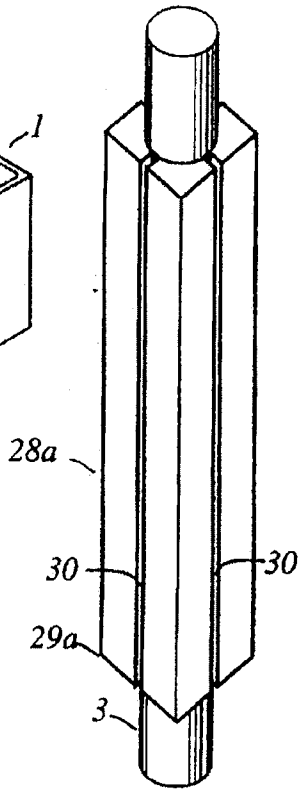


FIG.17a

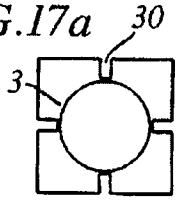


FIG.17b

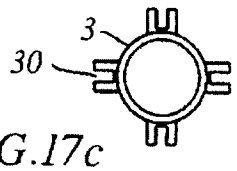
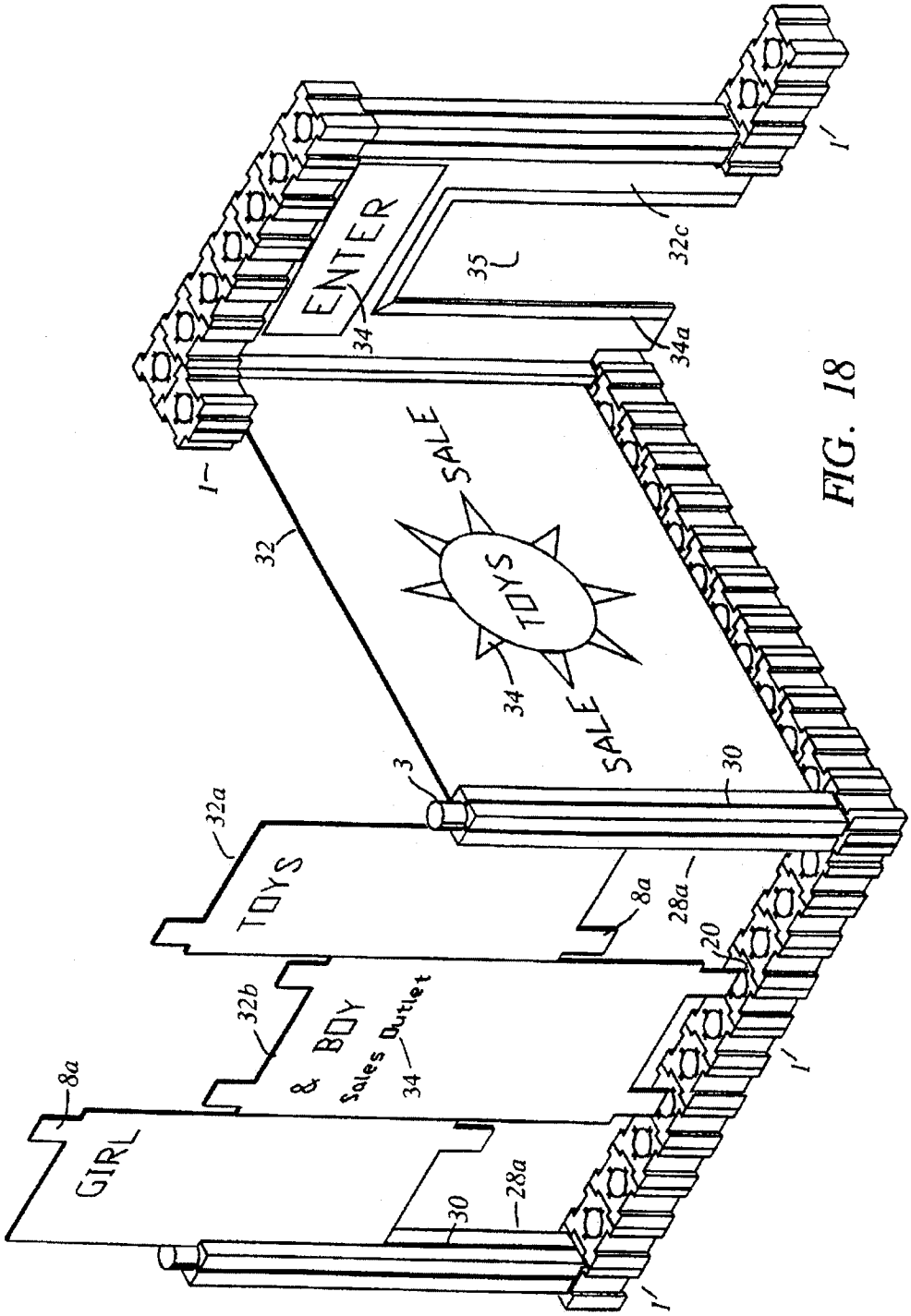


FIG.17c


ENTER
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TOYS
SALE
TOYS
& BOY
Sales Outlet
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32a
32b
32c
34
34a
35
3
30
28a
8a
20

FIG. 18

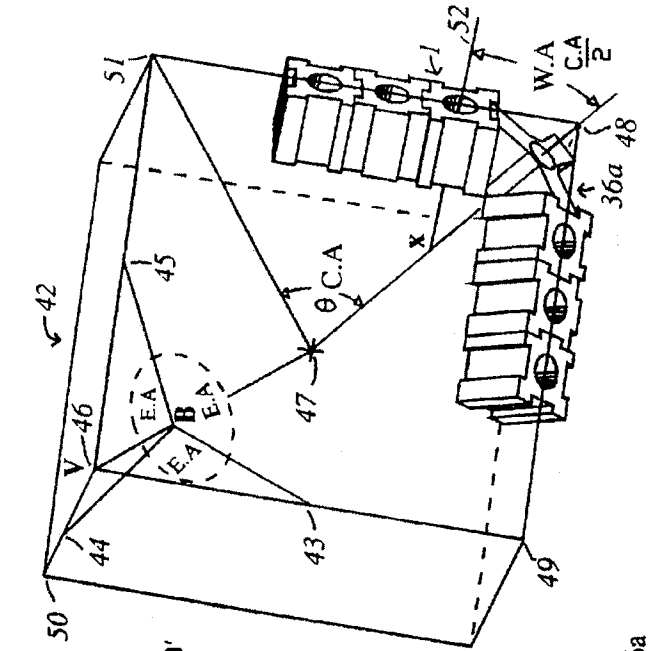

FIG.21

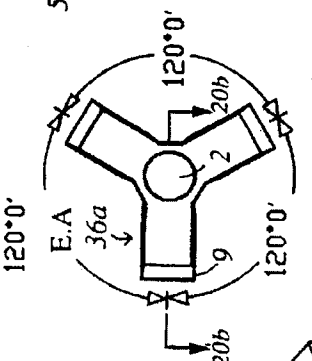

FIG.20a

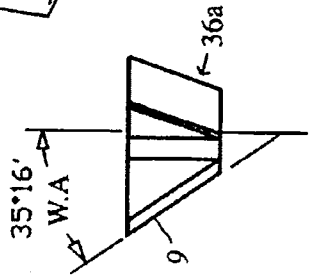

FIG.20b

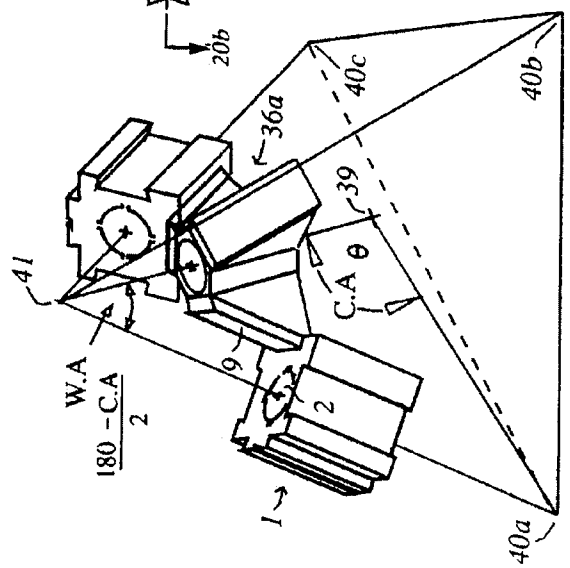

FIG.19

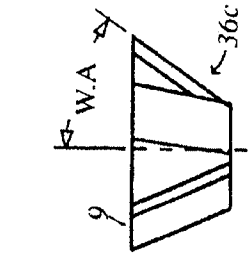

FIG.23b

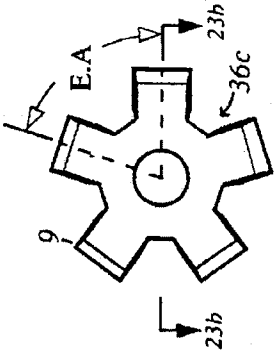

FIG.23a

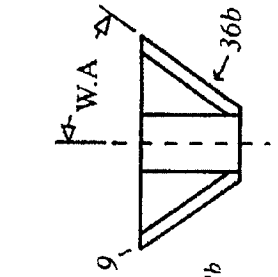

FIG.22b

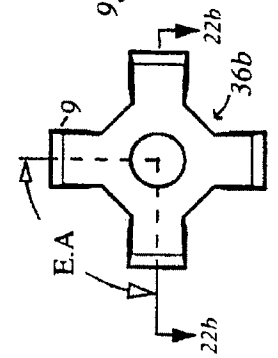

FIG.22a

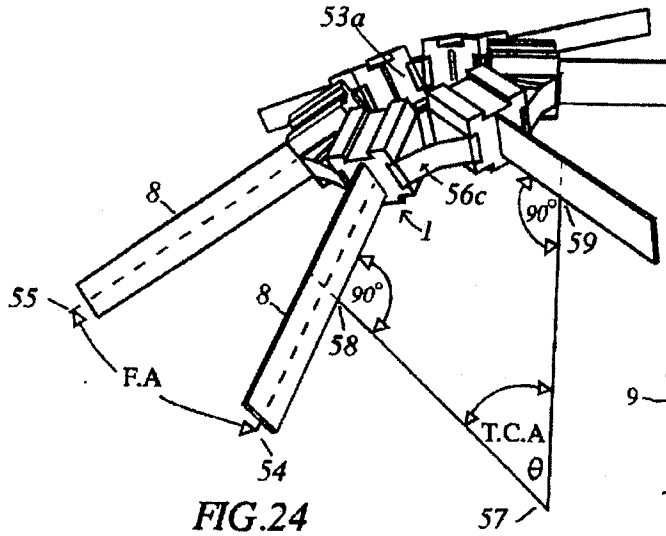

FIG.24

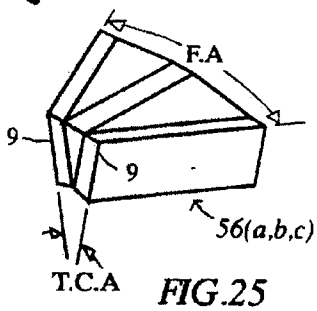

FIG.25

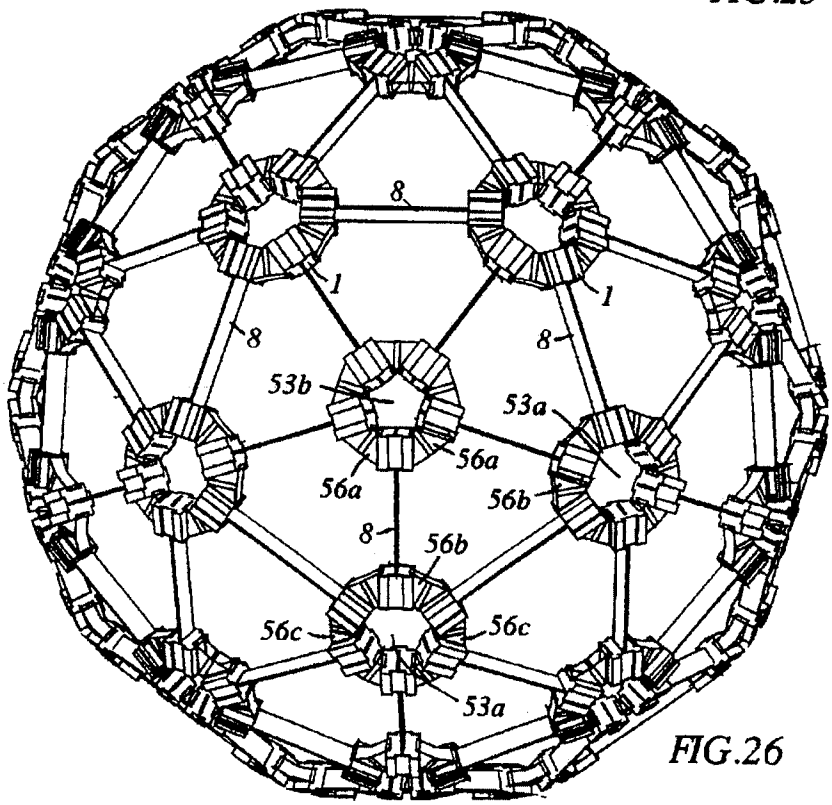

FIG.26

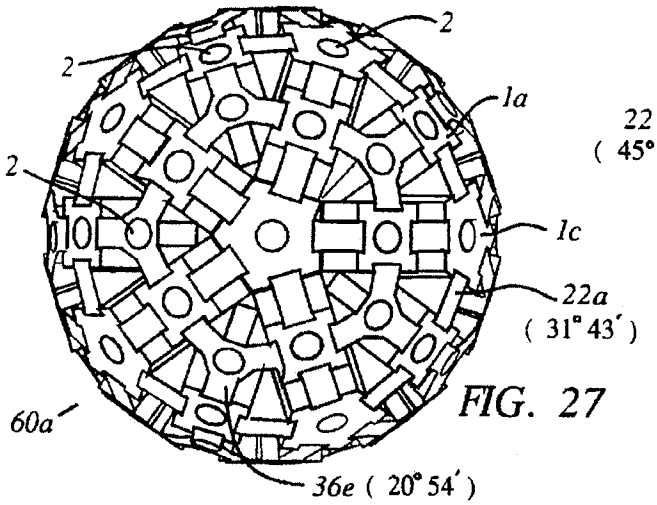

FIG. 27

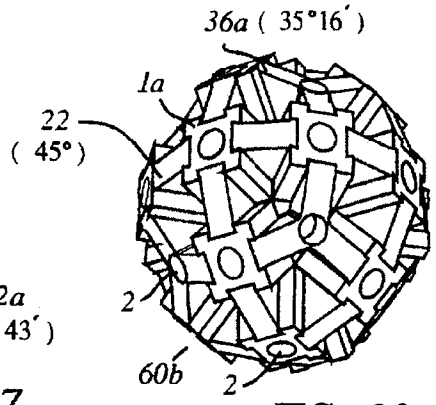

FIG. 28

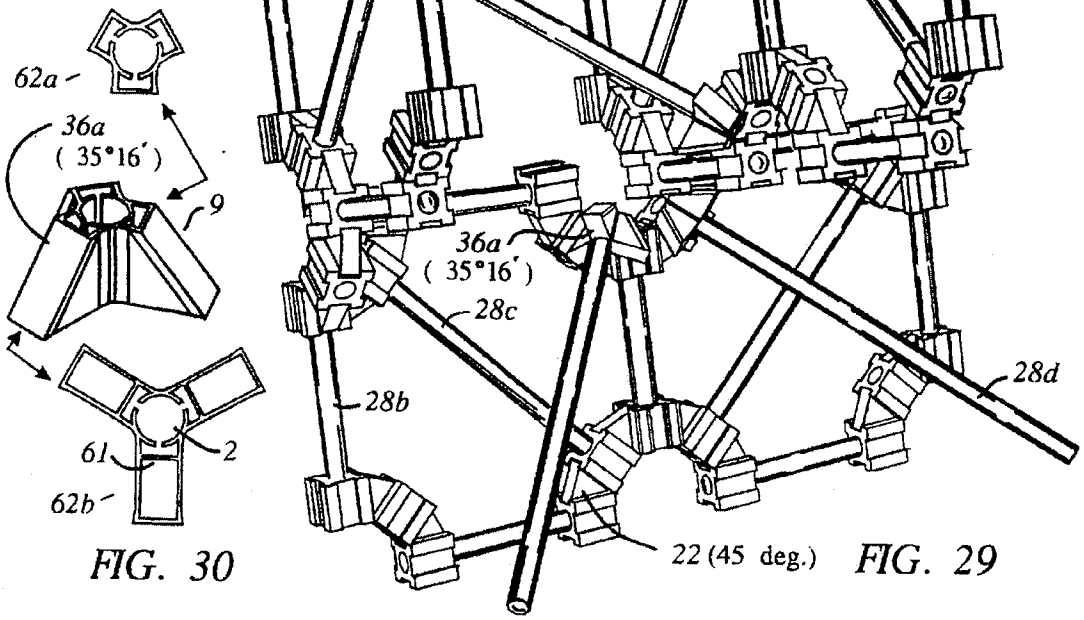

FIG. 30

FIG. 29

INTERNATIONAL SEARCH REPORT

In. .tional Application No
PCT/CA 97/00138

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A63H33/08 A63H33/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A63H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 93 10873 A (MADDOCK) 10 June 1993 see the whole document	1-30

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
22 May 1997	30. 05. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Lasson, C

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

In. ational Application No
PCT/CA 97/00138

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9310873 A	10-06-93	AU 2938192 A	28-06-93
		US 5527201 A	18-06-96